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CENTRAL INTELLIGENCE AGENCY

# INFORMATION REPORT

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COUNTRY USSR

SUBJECT Comments and Evaluations on Articles on Tempering and Grain Size-Steel

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1. Title: Carbide Precipitation During Tempering of Quenched Alloy Steel. Authors: V.I. Arkharov and S.T. Kiselev. Published by Doklady Akademii Nauk SSSR 59 (1948) no. 9, pp 1571/1574.

   a. A competent paper. Twelve alloy steels (with about 1 to 4% Cr, 0.2 to 1.3% Mn, up to 0.5% Mo, 0.3 to 2% Ni and up to 2.5% W) were quenched and tempered eight hours at 400, 500 and 600 C. After electrolytic separation of the carbides from these specimens (and also from annealed samples), the composition and structure of the carbides were determined.

      1. A "low-temperature phase" was found in all steels tempered at 400 C and in some tempered at 500 C. The diffuseness of the X-ray lines made the exact composition of this phase uncertain, but it appears to differ from Kurdyumov's "$Fe_xC$".

      2. There is a correlation between the presence of this phase and low toughness and intergranular fractures. It is possible that this finding may confirm a previous hypothesis on the cause of temper brittleness.

      3. At higher tempering temperatures, the "low-temperature phase" disappears with the appearance of other carbide phases. For an eight-hour temper, this change occurs at about 400 to 500 C. In some steels where the carbides found in the annealed condition are of the $Fe_3W_3C$ ($Cr_{23}C_6$) or $Cr_7C_3$ type, an "intermediate" carbide-namely, an alloyed cementite as, for instance, $(Fe,Mo)_3C$-is formed at the higher tempering temperatures.

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b. Considerable work has been done on the carbide phase precipitated at low tempering temperatures since Kurdyumov's original investigation. The latest work (on plain carbon steels) indicates that this phase, now generally called epsilon carbide, has the approximate composition $Fe_{2.4}C$.

C.S. Roberts, B.L. Averbach and M. Cohen: The Mechanism and Kinetics of the First Stage of Tempering. TASM 45 (1953) pp 576/699; disc 599/604

c. The reference to a hypothesis relating the presence of this low-temperature phase to temper brittleness is not clear as it refers to a previous paper. This could refer to either the so-called 500 F or A-embrittlement, or to the phenomenon generally called temper brittleness. In either case the hypothesis does not seem very tenable.

1. The first type of embrittlement takes place when quenched steels are tempered at about 250 to 400 C. (The latest of many theories is that this type of embrittlement may be caused by the occurrence of cementite films along martensitic plates lying at prior austenitic boundaries.) Since it is known from other work that the low-temperature phase is formed at temperatures below 250 C, there would appear to be no reason why there should be a relation between this phase and this particular type of embrittlement.

   B.S. Lement, B.L. Averbach and M. Cohen: Microstructural Changes on Tempering Iron-Carbon Alloys. TASM 46 (1954) pp 851/877; disc 877/881

2. The phenomenon known as temper brittleness occurs in some alloy steels when they are held in, or slowly cooled through, the approximate range 450 to 600 C. There are a number of arguments why the low-temperature phase is probably not involved here. Perhaps the simplest is that temper brittleness can occur in non-martensitic steels, whereas the low-temperature phase occurs only in steels quenched to martensite.

d. The carbides found at the higher tempering temperatures and in the annealed conditions are approximately those that would be expected from other work in this field.

W. Crafts and C.M. Offenhauer: Carbides in Low Chromium-molybdenum Steels. TAIME 154 (1943) pp 361/373

H. Krainer: Röntgenographische Untersuchungen der Sonderkarbide mehrfach legierter Stähle in geglühtem Zustande. Archiv für das Eisenhüttenswesen 21 (1950) pp 33/38

H. Krainer: Röntgenographische Untersuchung der Karbide in Wolfram-, Molybdän-und Vanadinstählen. Archiv für das Eisenhüttenwesen 21 (1950) pp 39/41

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2. Title: Changes in the Grain Size of Steel as a Result of Recrystallization. Authors: V I Arkharov and Yu D Kozmanov. Published by Doklady Akademii Nauk SSSR 69 (1948) No. 1, pp 33/35

a. Bochvar pointed out the effect transformation strains could have on the grain size produced on subsequent recrystallization. A recent Soviet investigation (Sadovskiy, Malyshev and V'yal) of the cause of abnormal grain growth in high speed steel confirmed the importance of this factor. Since metallographic examination was considered to be insufficiently accurate, X-ray analysis was used in the present study of the recrystallization of an overheated (coarsened) alloy carburizing steel (18 KhNMA).

1. The "recrystallization threshhold" was 1000/1020 C. Transformation strains affected recrystallization at lower temperatures but not at higher.

2. Heating to a temperature between the critical range and the recrystallization threshhold led to an orientation texture, and the steel still had a coarse fracture.

3. Heating to a temperature slightly higher than the recrystallization threshhold gave a fine grain size.

4. Heating to a significantly higher temperature caused a new grain growth of the recrystallized austenite.

b. While the results obtained probably apply to the particular samples tested, it is doubtful whether they have wider significance.

1. No details are given on the overheating treatment used to give the original coarsened structure, nor on the method of cooling from this treatment. Both of these would be expected to have a marked influence on subsequent recrystallization. The latter would presumably be of special importance in determining the magnitude of the transformation strains.

2. As discussed in a previous review of Braun and Voronov, there has been much work on the subject of overheated steel and methods of salvage. Nevertheless, there has been no agreement as to the utility of the various homogenizing and heat-treating schemes. If the results of Arkharov and Kozmanov were generally applicable, this would present a simple method of refining overheated steel. Other experimental data, however, indicate that this is not necessarily true.

M P Braun and P E Voronov: The Nature of Forging Overheating in Alloy Steel. Stal 6 (1946) pp 482, 485

3. In the investigations on overheated steel, pronounced differences have been found among heats of the same grade. It is hard to see how these variations would fit in with Arkharov and Kozmanov's theory.

c. Apparently Arkharov and Kozmanov's study was prompted at least in part by the cited investigation on the cause of abnormal grain growth in high speed steel.

1. It is not evident why there should be any connection between abnormal grain growth in high speed steel and the grain growth encountered in overheated steel. The former occurs only when hardened high speed steel is rehardened without an intermediate anneal. Prior condition is not a factor in determining the occurrence of the latter type of grain growth.

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2. Grobe, Roberts and Chambers have shown that the abnormal grain growth found with high speed steel does not occur in low-alloy and straight carbon tool and die steels, although it does take place in a 9% W hot-work steel. Most of the trouble with coarsening on overheating, on the other hand, has been encountered with medium and low-carbon low-alloy steels (such as the AISI and SAE grades).

   A H Grobe, G A Roberts and D S Chambers: Discontinuous Grain Growth in High Speed Steel. TASM 46 (1954) pp 759/788; disc 788/798

3. Even in the case of high speed steel, transformation strains are not involved in the theory based on the most recent experimental work in the USA.

   E Kula and M Cohen: Grain Growth in High Speed Steel. TASM 46 (1954) pp 727/752; disc 752/758.

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